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THE IMPROVEMENT OF QUALITY IN FIGS[1]

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The California fig industry has a serious problem in the high percentage of spoilage in the fruit. This condition has recently been accentuated by the action of federal authorities in decreasing the legal tolerance of infested figs. The present situation is not a new one but has existed for a long time. It has been previously described as follows:[4]

"The fig deserves to be one of California's best commercial fruits. It shares with the olive and grape the distinction of being one of the oldest cultivated fruits. It is nutritious, appetizing, of attractive appearance, and wholesome. The fruit has a great variety of uses, not only in the usual dried form, but also for eating fresh and in such manufactured forms as jam, marmalades, preserves, canning, candy, bakery products, breakfast and health foods, beverages and medicinal preparations. The well known salutary properties of dried figs lend themselves particularly well to advertising. The fig is one of the healthiest of fruit trees, easily suited as to soil and moisture, and well adapted to a wide area in California and (for dried figs) to no other portion of the United States. The quality of California-grown figs at their best is admittedly unsurpassed.

"And yet, it must be said that fig culture is not as well established in California as that of many other fruits, and considerable difficulty is experienced in disposing of the comparatively small dried-fig crop of the state at even moderate prices. . . . .

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[4] Phillips, E. H., E. H. Smith, and R. E. Smith. Fig smut. California Agr. Exp. Sta. Bul. 387:1–38. 1925.

"The greatest obstacle to the success of the fig industry at the present time is the occurrence of various forms of *rotting, souring,* and *molding* of the fruit, which at times become very abundant and troublesome, and for which no method of control has been found. Such defects reduce yields and make it very difficult to put up a high-grade, dependable pack of sufficient quality to compete on better than even terms with the foreign product and one upon which the arts of advertising and salesmanship can confidently be practiced. It is only by such advertising, backed by superior, uniform quality that our increased production of other foreign-competing fruit products has been successfully marketed."

The Experiment Station has for several years been engaged in a study of fig troubles, with considerable financial assistance from the California Peach and Fig Growers Association. Miss Phillips began the work in 1920. She and Miss Smith were the first to indicate clearly that the rotting and spoiling of figs in the orchard is not an ordinary process of decay or the effect of weather conditions, but that there are certain specific troubles or diseases, each with a definite cause and process of development. Their work suggested certain fundamental facts which later investigations have proven to be correct. The following principles may be considered as established: (1) The rotting of figs is caused by different kinds of fungi, bacteria, yeasts and similar organisms, which start to develop inside the fruit. (2) The decay germs are carried into the figs by insects; a fig is always sound and sterile unless it has been entered by some insect. (This might not apply to figs which had been rained on or had lain on wet soil.) (3) Almost all the trouble starts while the figs are still on the tree and not after they have fallen to the ground. (4) The rotting or souring of figs is not caused by weather conditions, soil moisture, or irrigation, but these conditions may hasten or retard the trouble by causing the figs to ripen and dry more or less slowly. P. D. Caldis[5] followed with further investigation of fig troubles. Agents of the Bureau of Entomology of the United States Department of Agriculture have recently been assigned to work on fig troubles, through the efforts of the Dried Fruit Association of California.

At a meeting of fig growers held recently in Fresno, resolutions were adopted urging the continuation of all this work and requesting the Director of the State Department of Agriculture to take the lead in an effort toward improving the fig situation. This paper has been prepared for the purpose of bringing together in a brief form what is

[5] Caldis, P. D. Etiology and transmission of endosepsis (internal rot) of the fruit of the fig. Hilgardia 2:287–328, 16 pl. 1927.

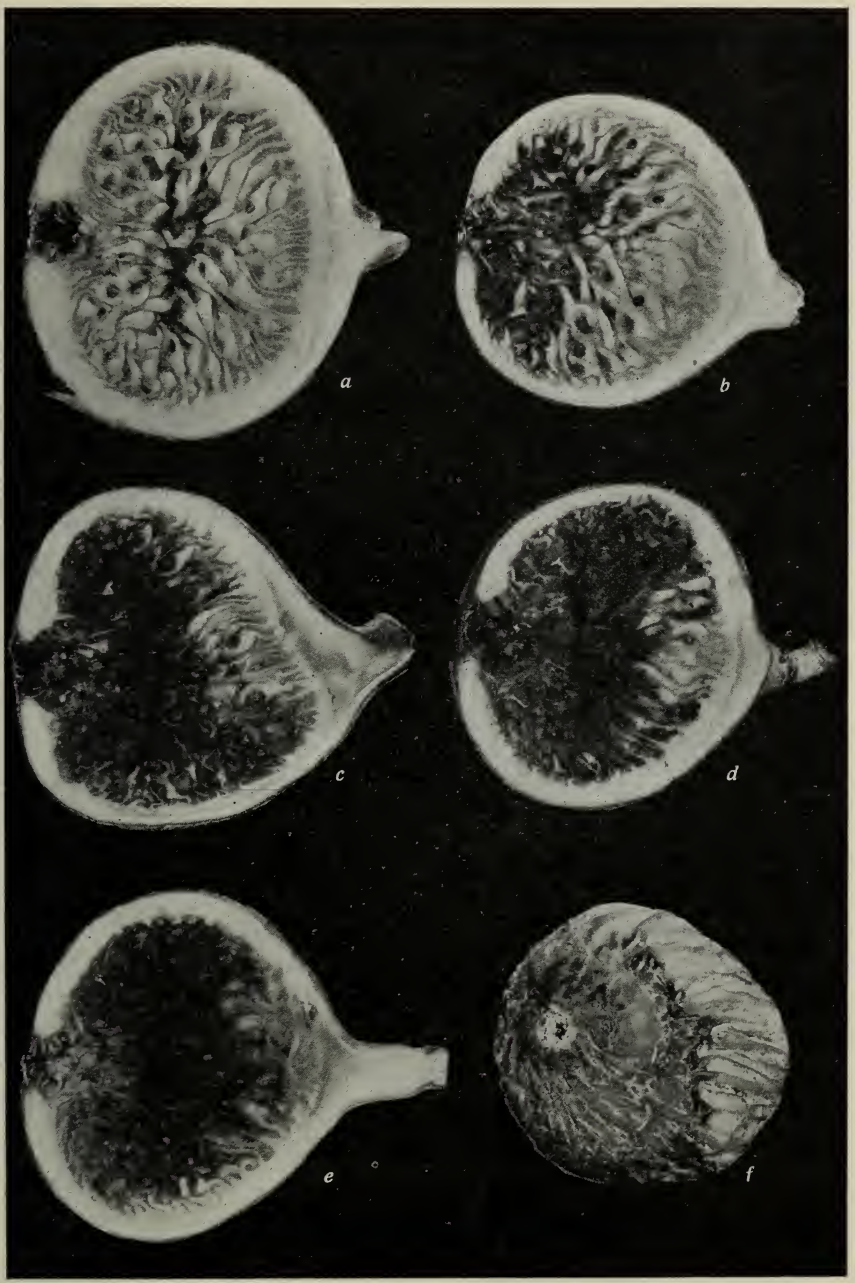

Fig. 1.—Interior of ripe Calimyrna figs with endosepsis.
(From Hilgardia, Vol. 2, No. 7.)

known about these fig troubles, their nature and cause, and the possibilities of controlling them.

The principal troubles affecting figs in the orchard are certain specific forms of rotting or spoiling of the fruit, most important of which are those called endosepsis (brown rot, internal rot) souring, smut and mold.

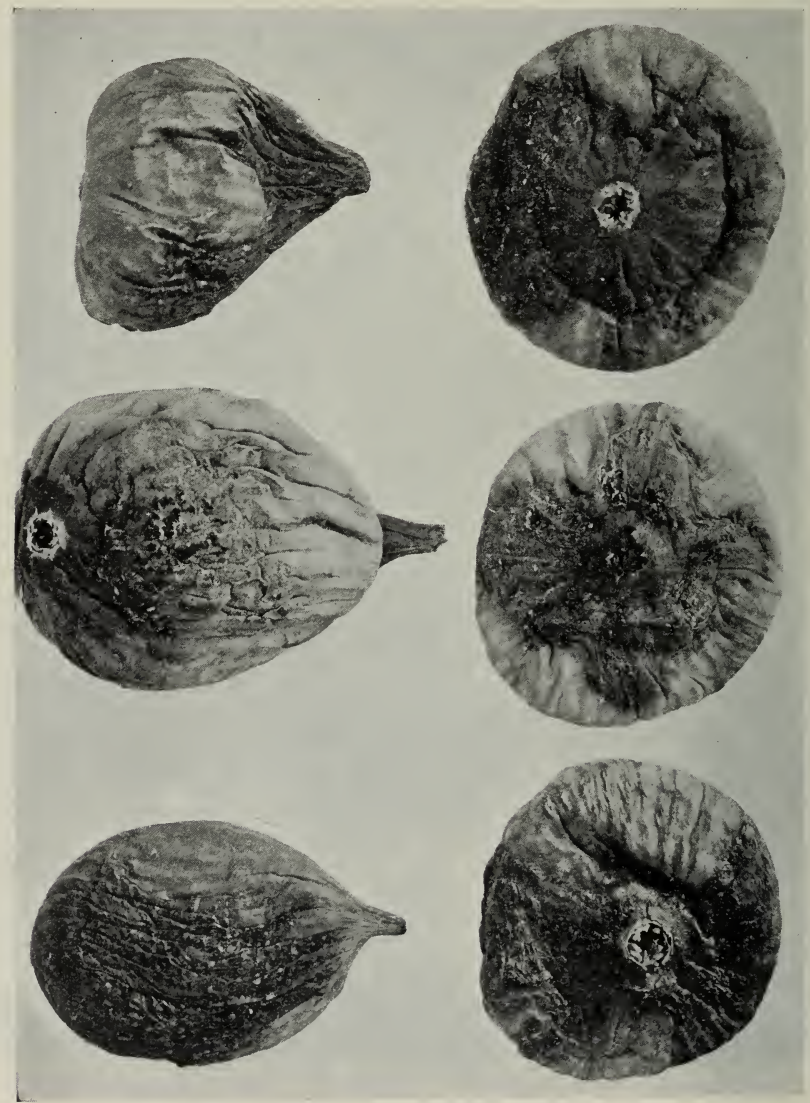

Fig. 2.—Dried Calimyrna figs showing the dark ends which indicate endosepsis. (From Hilgardia, Vol. 2, No. 7.)

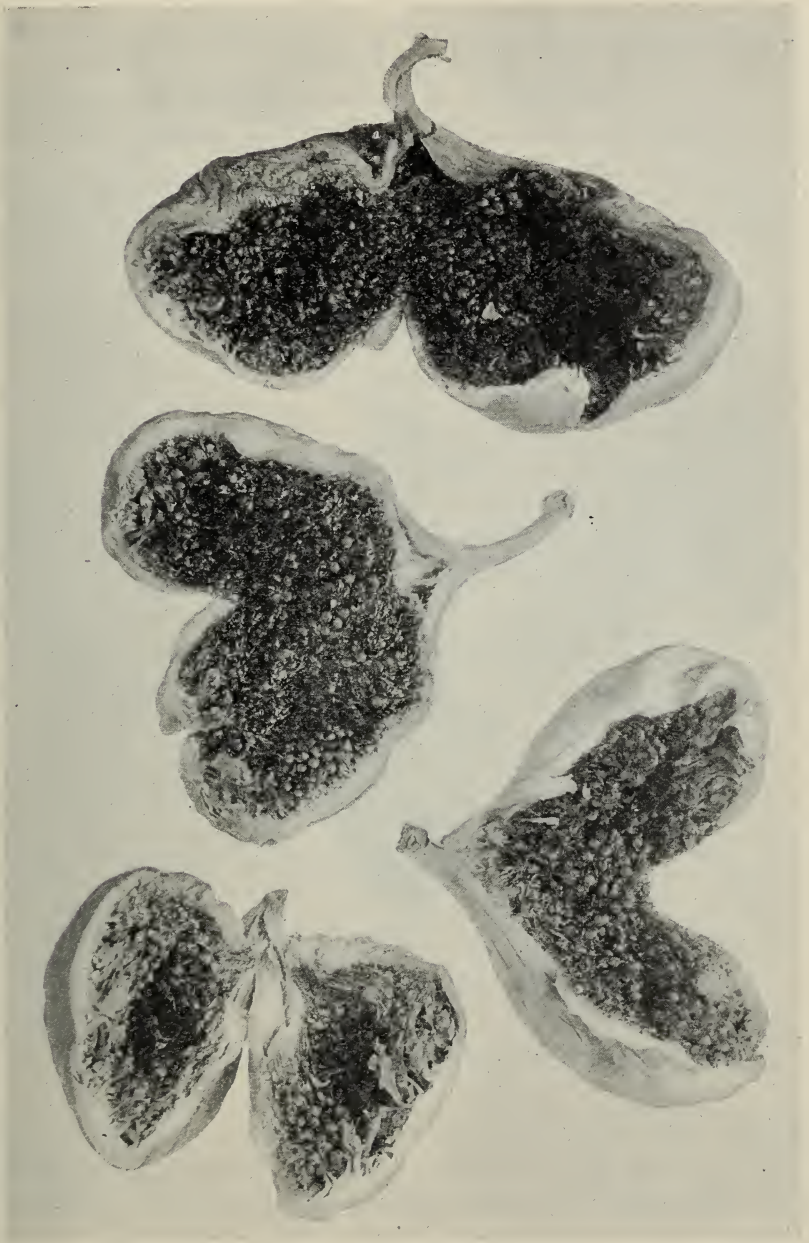

Fig. 3.—Interior of dried figs affected with endosepsis, showing the hollow, seedy condition. (From Hilgardia, Vol. 2, No. 7.)

ENDOSEPSIS (BROWN ROT, INTERNAL ROT)

This is a rot affecting the Calimyrna or any other fig which has been caprified by the *Blastophaga* wasp.[6] As the fig ripens there develops in the flesh a brown, watery form of decay (fig. 1). There is no very bad odor or disagreeable flavor unless this disease is complicated with other forms of rot. Only caprified figs are typically

Fig. 4.—The female blastophaga enlarged twenty-seven times. (From Bulletin 319.)

affected. The inside of the dried fig becomes dark-colored and hollow, containing little pulp but mostly seeds (figs. 2 and 3). Many caprified figs become affected with both endosepsis and souring or other rots.

Cause.—The rot is caused by a white fungus which does not form a conspicuous mold in affected figs. The spores of this fungus are

[6] Condit, I. J. Caprifigs and caprification. California Agr. Exp. Sta. Bul. 319:341–377. 1922.

carried by the blastophaga from one generation of caprifigs to another and thence to the edible crop (fig. 4). The fungus grows mostly on the blossom parts just inside the eye of the caprifig. When the female blastophaga passes out, some of the spores stick to her wings (fig. 5). In entering another fig she brushes off some of these spores on the

Fig. 5.—Portion of a wing of the female blastophaga, much enlarged, showing the tiny, white fungus spores among the black spines.

flowers or bud scales (fig. 6). Often there is quite an accumulation of dead blastophagas and wings just inside the eye, and this makes a good starting point for the fungus (fig. 7).

Caldis found that all parts of the state are infested with this fungus and that it is probably in every caprifig tree in the state and in most of the individual caprifigs. He proved beyond all question that it is the blastophaga which carries the fungus into the Calimyrna figs and that it comes from the caprifigs (fig. 8).

Control.—The only conceivable way of preventing endosepsis in caprified figs is to obtain blastophagas or caprifigs free from the fungus, if such a thing is possible. For this seemingly hopeless task several promising methods have been discovered. It is evident that in any method of using clean blastophagas a district must be chosen

Fig. 6.—The largest figs in the illustration are mamme figs from which the blastophagas are issuing. The four smaller figs at the tip of the branch are profichi figs of sufficient size for the female insects to enter and oviposit. Note the female blastophagas on the surface of the fruit. They carry the spores of the endosepsis fungus on their wings from the mamme to the profichi and from the profichi to the edible figs and mammoni. (From Bulletin 319.)

which is out of flying range of blastophagas from any untreated area or caprifig trees, and all the caprifigs in the district must be treated or destroyed in order to get 100 per cent results. An individual grower or district may do some good by working alone, but the results will vary according to the number of infested blastophagas that drift in.

Demonstrations of 1927.—In one demonstration during the past season an area of about a square mile just east of Modesto was chosen. In this area there were six fig growers and a total of seventy-five capri fig trees and fifty acres of Calimyrnas. The area was fairly well iso-

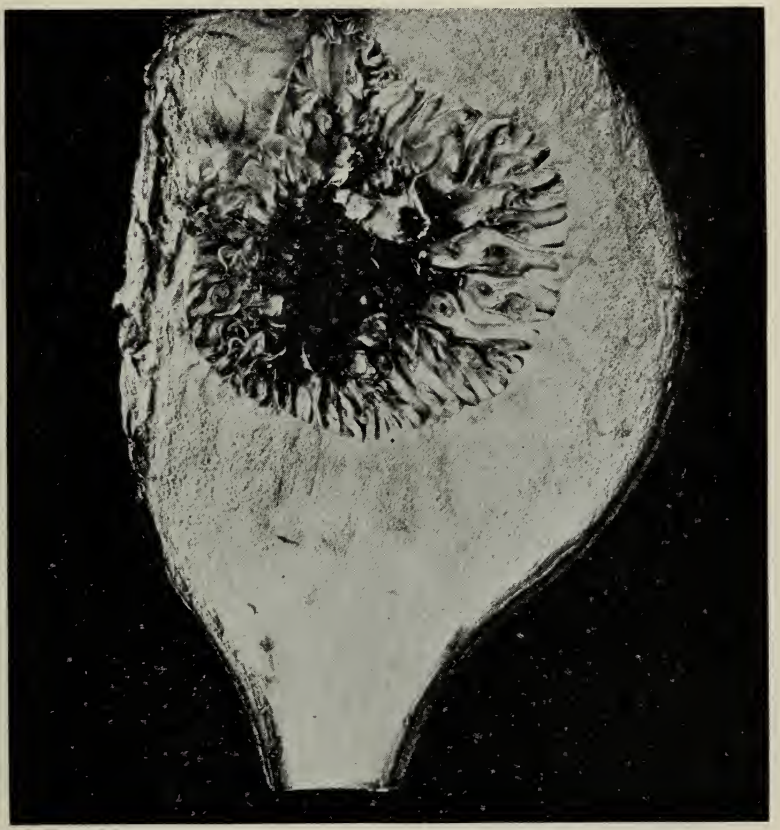

Fig. 7.—Section of a caprifig, somewhat enlarged. The female blastophaga, in entering such a fig, brushes off spores of the endosepsis fungus from her wings onto the scales and florets. The fungus develops here, and when the new generation of blastophagas emerge they pick up the spores again and carry them on to the next crop of figs. By treating the inside of the fig with a disinfectant, either by injecting it or splitting and dipping, the fungus is killed, but the insects in the galls are not injured. No pollen is required from the mamme to set the profichi.

lated from other caprifigs, especially to windward, although there were trees in various directions within one mile. A careful survey was made to locate all the caprifig trees in the area and as soon as the leaves were off in the fall most of the figs (mamme) were removed from the trees,

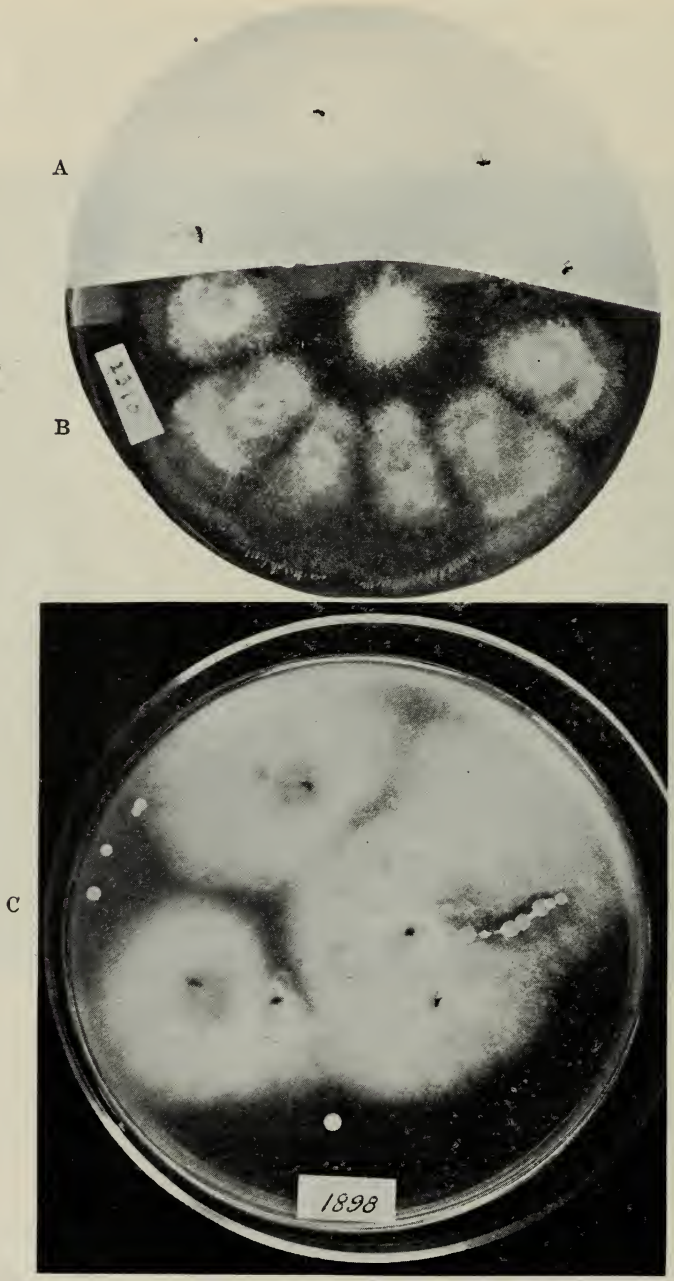

Fig. 8.—Culture plates showing, *A*, a section of a plate with insects from disinfected mamme fig, with no fungus growth (the blastophaga on the left shows a slight development of bacteria); *B* and *C*, the growth of endosepsis fungus from blastophagas from untreated figs.

leaving a few on some of the smaller trees for treatment (fig. 9). During January and February these reserved figs were treated on the tree by injecting each one through the eye with a fungicidal solution by means of a hypodermic syringe. Culture tests showed that it was possible by this method to kill the fungus in the mamme figs completely without injuring the figs or the insects in the galls. Some of the growers had contracted for caprifigs on trees in other places. These trees were treated in the same way, removing most of the mamme figs and injecting the remainder. In the large caprifig orchard

Fig. 9.—A Milco caprifig tree showing the mamme crop which must be removed and destroyed or treated in order to eradicate endosepsis. (From Bulletin 319.)

of the Fig Association at Orosi most of the mamme figs were removed and the remainder treated. In other cases isolated capri trees were entirely stripped and recaprified with the injected figs from other places. In these cases the treated figs were left on the trees until maturity, then removed and hung in the trees to be caprified, in order to get a clean profichi crop.

The hypodermic injection method of treatment had the advantage of being practically 100 per cent effective in disinfecting the figs but had certain very serious disadvantages for work on a large scale. The method is very slow and would require a corps of several hundred

trained men to cover a large district. The operation requires considerable skill. It is easy to miss some of the mamme figs on the trees and leave them untreated. Most mamme figs, at the time when the injection should be done, are very solid and hard and difficult to inject. The method is not practical for any large area.

The control of endosepsis was also tried in 1927 in two comparatively isolated Calimyrna orchards, one near Merced and one near Madera. In the latter a somewhat different method was used. All the mamme figs in the orchard were stripped off and in another, isolated place mammes were left on the trees until they commenced to soften and mature and the insects were beginning to emerge; then these figs were removed, cut in two, and soaked in the disinfecting solution for about fifteen minutes. These pieces were then put into baskets and hung in the trees as usual.

This method has the advantage of being rapid and requiring no particular skill. A serious disadvantage is that the mamme figs which are to be treated must be left on the trees until they are mature before they can be taken off, split, and dipped. Consequently before the figs are picked some infested blastophagas will escape and contaminate the profichi in that vicinity. That area will then have to be cleaned up the following year. It would be ideal if all the mamme figs in the fig-growing districts could be stripped off and enough mamme for disinfecting and recolonizing be obtained in distant places where no edible figs are grown. Unfortunately, there are not enough caprifigs in such places to recaprify the whole San Joaquin Valley.

Another difficulty is that figs thus treated are not permanently disinfected; some of the fungus may be alive down deep in the tissues and grow out again to the surface. Consequently, the dipped figs which are hung in the trees for caprification must be taken out again and destroyed at the end of five days. Some of these might easily be overlooked and the later blastophagas which come from them might then get infested with the fungus and infect the profichi. If the figs are picked and dipped early, say 30 days before maturity, the insects will not emerge normally at the proper time.

In the Modesto orchards it was necessary to bring in extra profichi figs. These came from the Orosi orchard which was exposed to infection from outside caprifigs. Consequently these figs were not entirely clean. All the demonstration orchards showed less than 5 per cent endosepsis in the total crop, the figs being very much better than those of any other orchard examined in 1927, or those in the same orchards in past years.

A New Plan: Obtaining Clean Blastophaga by the Insectary Method.—A new plan has recently been devised by the junior author by which all the mamme figs in the state (or in the area to be handled) would be removed from the trees at least 30 days before maturity and shipped to an insectary in a central place where no blastophagas could escape to any caprifig trees. There the figs would be stored and disinfected by the dipping method. By the use of proper equipment and by application of heat, the insects at the proper time would be made to emerge into sterile vials or containers in which they might be shipped to any part of the state and placed in the trees to caprify the profichi crop (fig 10). This method would make it unnecessary to remove any treated figs from the trees, furnish almost limitless numbers of clean blastophagas and allow of cleaning up the whole territory in one season. It is the most scientific method which has yet been suggested, and the only one which would be practical for a large area. It would, of course, need extensive trying out before it could be considered as completely perfected, but many parasitic insects are handled in this way with perfect success, and the methods of such work are already highly developed. Preliminary tests have shown that blastophagas will live in glass vials for more than two weeks and that they can be kept dormant by chilling with ice.

Possibilities of State-wide Control.—It is now proposed to carry out a state-wide or valley-wide cleanup of endosepsis. This is a far greater task than the control of the disease in a single district. It is a task which should only be undertaken on the assumption that a crisis exists and that radical action is therefore necessary. Neither the State Department of Agriculture or the University has any reason to suggest or promote such a procedure save at the urgent desire of the industry. In the former experiments all the growers agreed to submit their trees to the treatment and all the work was personally supervised. As the area treated was so small it was possible to get plenty of mamme figs in other places for treatment. Even in this small area and under careful supervision it was very difficult to locate all the caprifig trees and to find and remove every single fig. In fact, some figs and even a few trees were missed.

In order to carry out any general control of endosepsis the work must be done very systematically, extremely thoroughly, and under legal authority. The only agencies having the power and organization to do this are the State Department of Agriculture and the County Horticultural Commissioners. Many details, such as whether or not a charge should be made for clean blastophagas, how to allocate these

Fig. 10.—Clean blastophagas in glass vial as used in new method to caprify profichi crop.

fairly, how to handle the expense of treating and distribution, and similar questions would have to be settled by mutual consent of the interested parties. It should be understood that no extensive campaign of this sort has ever yet been attempted and that unforseen difficulties might easily arise to prevent complete success, if eradication of endosepsis over large areas at one time is undertaken. The methods will undoubtedly be improved by further experience in many of the details of the work. If a state-wide campaign is attempted there would be some possibility of a shortage in the next profichi crop. Growers would have to take this chance as being better than having a full supply of ordinary infected caprifigs. The whole question is whether the situation is bad enough to take a chance on imperfect results for one year in order to start on an extensive scale.

With the insectary method of disinfection, the following procedure would be necessary: (1) Make a complete survey and locate every caprifig tree and graft in the area. This would require a house-to-house and orchard-to-orchard inspection. (2) Before February 15th go over all the capri trees and remove every mamme fig or destroy the trees. Very careful inspection is required to find every fig, especially on large trees. There are many large, old trees where it would be absolutely impossible to remove all the figs, and either the whole tree or the top would have to be cut off and burned. (3) Send the mamme figs to the central insectary for treatment, or, if not needed, they should be destroyed. No caprifigs should be dropped on the ground under the trees and allowed to remain there as the infested blastophagas might live over in them and enter the profichi. (4) In the insectary, the mamme figs would be stored in a cool place with proper humidity until caprification time. Then, as the blastophagas are needed, the figs would be split in two, dipped in the fungicide, and placed in warm chambers at the proper temperature to cause the insects to emerge. The female blastophagas would be caught in sterile vials and shipped out to the growers. If necessary they could be kept dormant by cold and held in storage. Enormous numbers of clean blastophagas could be obtained by this method and the grower could be furnished with an abundant supply for the profichi crop. The latter would be distributed and handled as usual to caprify the Calimyrna figs.

SOURING

It should be clearly understood that endosepsis is not the only fig disease; other troubles are also very serious. Even with a complete elimination of endosepsis there would still be many bad figs. A really successful solution of the present fig problem would require the control of at least one other disease—that called souring.

Fig. 11.—Sour fig.

This is a form of spoilage in figs in which the contents of the ripe fruit ferment and sour, and liquid drips from the eye (fig. 11). The dried fig is hollow and has a sour taste and odor. The outside is shrivelled and discolored in a more or less typical way. The conditions called 'blue stem,' 'black neck,' and 'black end' in dried Adriatic figs are caused by souring (fig. 12). Figs with endosepsis may also be

affected with souring. Of the commercial fig varieties in California the Adriatic and Calimyrna are most liable to souring, while the Black Mission and Kadota are very free from the trouble.

Cause.—Souring is caused by yeast, followed by the action of bacteria and molds. It is started by insects, especially the dried-fruit beetle (*Carpophilus hemipterus*), entering the figs. It is spread by these and other insects, especially the vinegar fly, *Drosophila.* The

Fig. 12.—Sour figs dried on tree, showing 'black-neck,' 'blue-stem' and 'black-end' conditions.

beetles breed throughout the year in decaying fruit of all kinds where they become contaminated with yeasts and other decay-producing organisms. They then enter the figs and start the trouble there. That the Mission and Kadota figs are less affected by souring than other varieties is due to the fact that the eye of the fruit is too small to allow the beetle to enter.

Control.—Control of the dried-fruit beetle is probably the secret of the prevention of souring. Sanitary methods, such as the cleaning up of all refuse fruit material in the vicinity of fig orchards should be strongly emphasized. Often a few cull oranges (fig. 13), decaying

Fig. 13.—Dried-fruit beetles issuing from decaying orange, covered with disease germs and ready to attack figs. (From Bulletin 387.)

melons (fig. 14) or thrown out lemon halves contain hundreds of these insects ready to invade the figs and loaded with fungus spores, yeasts, and bacteria. Miss Phillips[7] found that the following list represents a typical menu for these insects during the year at Fresno.

November-March—
Figs, all kinds and conditions.
Melons, fermenting and molding.
Apples, rotting on ground.

April—
Prunes, old, in packing house.
Apples, in dump and under trees.
Oranges, on ground under trees.
Melons, decaying in field.

May—
Oranges, on ground under trees.
Figs, old culls in dry yard.

June—
Figs, old culls in orchard.
Oranges, on ground under trees.
Grapefruit, culls on ground.

July—
Figs, Cordelia variety, fresh, ripe, sound, and sour.
Mission, moldy, first crop on ground under tree.
Old culls, on ground near fig orchard.
Brunswick variety, first crop, both sound and sour.
Kadota variety, first crop, sour.
Peaches, ripe, on ground.
Apricots, ripe, rotted by smut fungus.
Tomatoes, ripe and moldy.

August—
Apples, rotting on ground, infested with worms, and various molds, including smut fungus.
Melons, fermenting and moldy, smut fungus present.
Figs, Adriatic variety, sound, souring, moldy, and smutty.
Kadota variety, both sound and sour.
Peaches, fermenting and rotting, smut fungus present.
Plums, like peaches.
Pears, wormy, rotting, and fermenting.

September—
Figs, Calimyrna, Kadota, and Adriatic varieties, sound, souring, rotting, moldy, and smutty, both on trees and ground.

October—
Figs and other fruits, all kinds and conditions, many souring, moldy, and smutty.

Every effort should be made to clean up all such material as the above in the vicinity of fig orchards before the crop begins to ripen.

[7] Phillips, E. H., E. H. Smith, and R. E. Smith. *Loc. cit.*

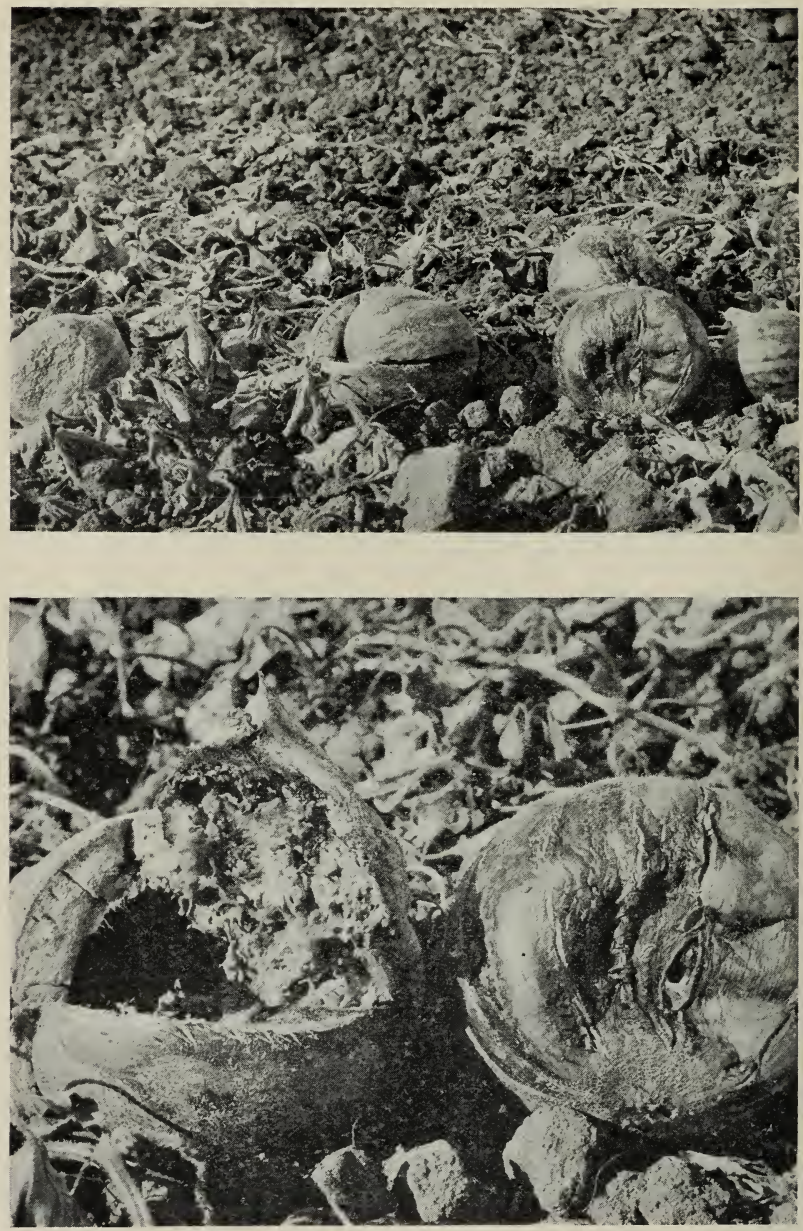

Fig. 14.—Old melons in field near fig orchard, furnishing abundant supply of dried fruit-beetles and germs of decay. (From Bulletin 387.)

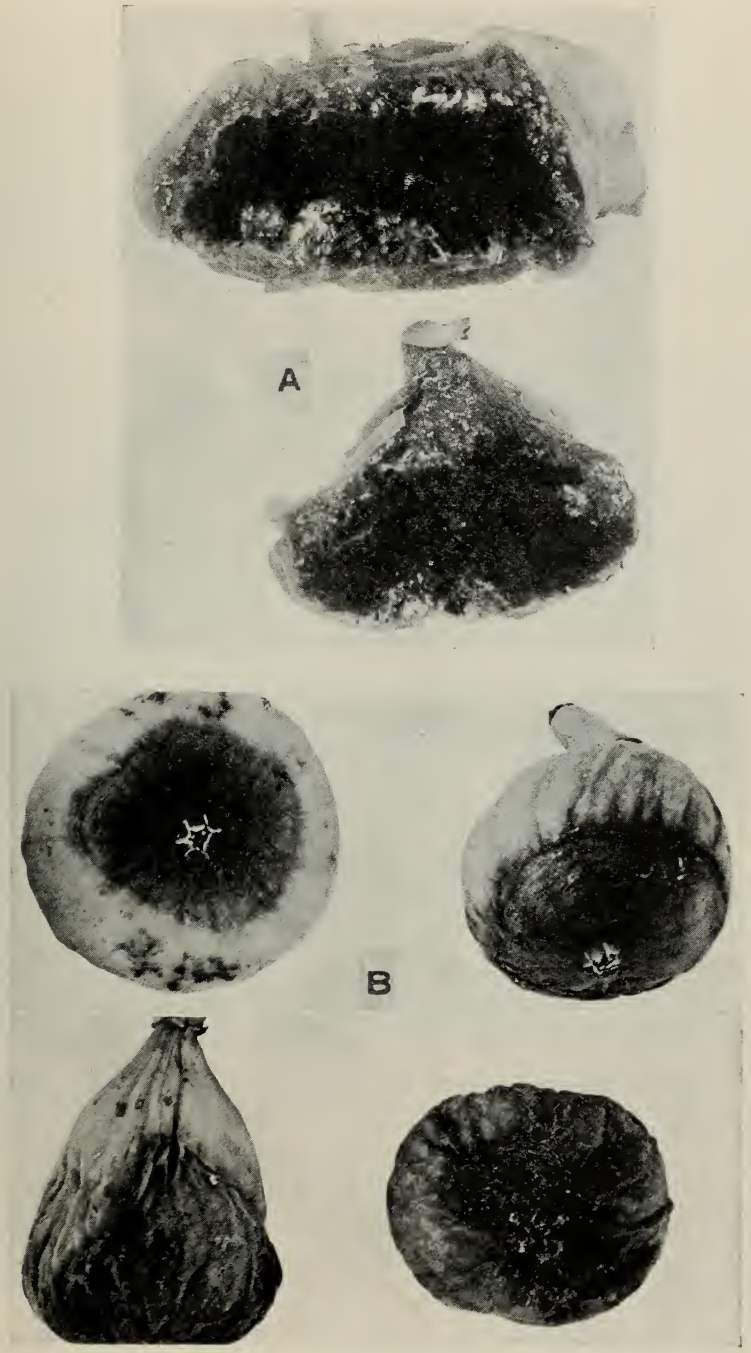

Fig. 15.—Smut in Adriatic figs. A, interior; B, exterior. (From Bulletin 387.)

SMUT

In this disease the inside of the ripe fig is partially filled with a black, dusty, mold fungus (fig. 15).

Cause.—Smut is caused by the common black mold fungus, *Aspergillus niger*. Its spores are usually carried into the figs by dried-fruit beetles which come from old rotting fruit on which this and other molds are growing (fig. 16).

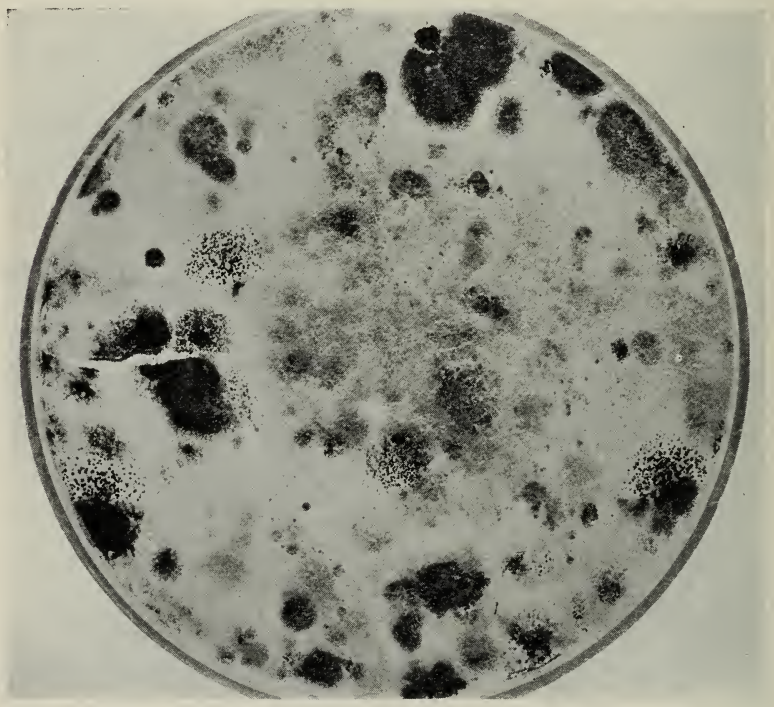

Fig. 16.—Culture plate in which a dried-fruit beetle was placed, resulting in abundant growth of molds, yeast, and bacteria. The black-dot areas are the smut fungus.

Control.—Control of smut is to be accomplished by the same method as that of souring, namely, eradication of the dried-fruit beetle and insects of similar habits, by cleaning up all their food material, and by trapping.

MOLD

Many dried figs are found to contain molds of various sorts, green, white, brown, black, and other colors. These also, to the best of our knowledge, are mainly started by the dried-fruit beetle and the prevention of this sort of trouble will be largely brought about by the suppression of such insects.

SUMMARIZED DIRECTIONS FOR IMPROVING THE QUALITY OF FIGS

1. Destroy all unnecessary caprifig trees. Keep caprifigs away from Missions, Kadotas, and Adriatics.

2. Cooperate with the County Horticultural Commissioner and Inspectors in whatever plan is adopted for cleaning up the mamme crop. Do whatever they ask cheerfully, promptly, and thoroughly.

3. Destroy every particle of rotten fruit, old dried fruit, and similar material near the fig orchard. This includes old caprifigs in baskets. Look for anything which harbors dried-fruit beetles and vinegar flies.

4. Keep in touch with the experiments being made at Fresno on the control of these insects at the Dried Fruit Insect Laboratory of the United States Department of Agriculture.

5. Keep the ground beneath the trees clean and dry during the harvest time.

6. Do not shake the trees, but let the figs get as dry as possible before they drop.

7. Pick up the figs frequently, every day if possible.

8. Do not leave bad figs on the ground but pick them up separately from the good figs and destroy them.

9. Do not dip, wash, or wet the figs unless required to do so by the packer.

10. Deliver the dried figs promptly to the packer. Do not keep them stored in barns or sheds.